A NEW FOSSIL ISOCRINID CRINOID FROM THE LATE OLIGOCENE OF WAITETE BAY, NORTHERN COROMANDEL

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Abstract. A new species of the crinoid *Nielsenicrinus* is described from the late Oligocene Torehina Formation, Coromandel, North Island, New Zealand. It lived in an inner-shelf, marine paleoenvironment no deeper than 50 m.

During fieldwork in Waitete Bay, Coromandel, on 22 December 1992, crinoidal remains were collected from a sandy, flaggy limestone of the Torehina Formation (Kear 1955) of Duntroonian age, near the Duntroonian-Waitakian boundary (Late Oligocene, about 25 million years). Although many fossil isocrinid columnals have been recovered in New Zealand (with some being described from the Triassic; Bather 1917), this is the second formal description of a New Zealand Tertiary isocrinid. Site locality number (S10/f6, Fig.1) is that of the Geological Society of New Zealand's archival Fossil Record File; grid reference is S10/ 289010 (NZMS 260 1: 50 000 map). Crinoid stem terminology follows Moore, Jeffords & Millar (1968), Roux (1977), Ubaghs (1978) and Webster (1974).

Hutton (1873) formally described the isocrinid *Pentacrinus stellatus* from the Oamaru Formation of Southland. It has since been recorded from several other New Zealand localities, among them the Chatham Islands, Curiosity Shop in Southland, and Point Elizabeth in Westland (Figs. 5, 7). It has also been reported from strata at Wilton Bluff and Aldinga Cliffs, South Australia. McKay (1897), Park (1897), and MacLaren (1900), all reported *Pentacrinus stellatus* columnals from the Torehina marine beds of Waitete Bay (Fraser & Adams 1907). Close examination of these columnals and pluricolumnals shows them not to be *Pentacrinus* but diagnostic of the genus *Nielsenicrinus*. *Pentacrinus* is now known to have become extinct in the Late Jurassic (Simms 1988). Tertiary "*Pentacrinus*" columnals have subsequently been distributed among other genera. "*P.*" *stellatus* has yet to be studied from this point of view.

There are many differences between the Waitete Bay species and "*P.*" *stellatus*; overall height of "*P.*" *stellatus* is 0.5-1.6 mm, compared with 0.5-2.7 mm for the Waitete Bay species. The columnal face of "*P.*" *stellatus* is a level plane whereas that of the Waitete Bay species is slightly raised at the centre of the higher columnals. Radial depressions are reduced in "*P.*" *stellatus* but distinct in the Waitete Bay species; longitudinal furrows do not transect the articular face of the former but do in the latter species. The columnal articular face of "*P.*" *stellatus* possesses short, oval, inter-radial petals, each surrounded by 20-22 culmina; the Waitete Bay specimens have long, elliptical, inter-radial petals each surrounded by 26-28 culmina. Crenellae do not reach their greatest length at the transition from marginal to adradial position in "*P.*" *stellatus*, whereas they do in the Waitete Bay species. The lumen is circular in "*P.*" *stellatus*, but sub-pentagonal in the Waitete Bay species. The morphological disparity

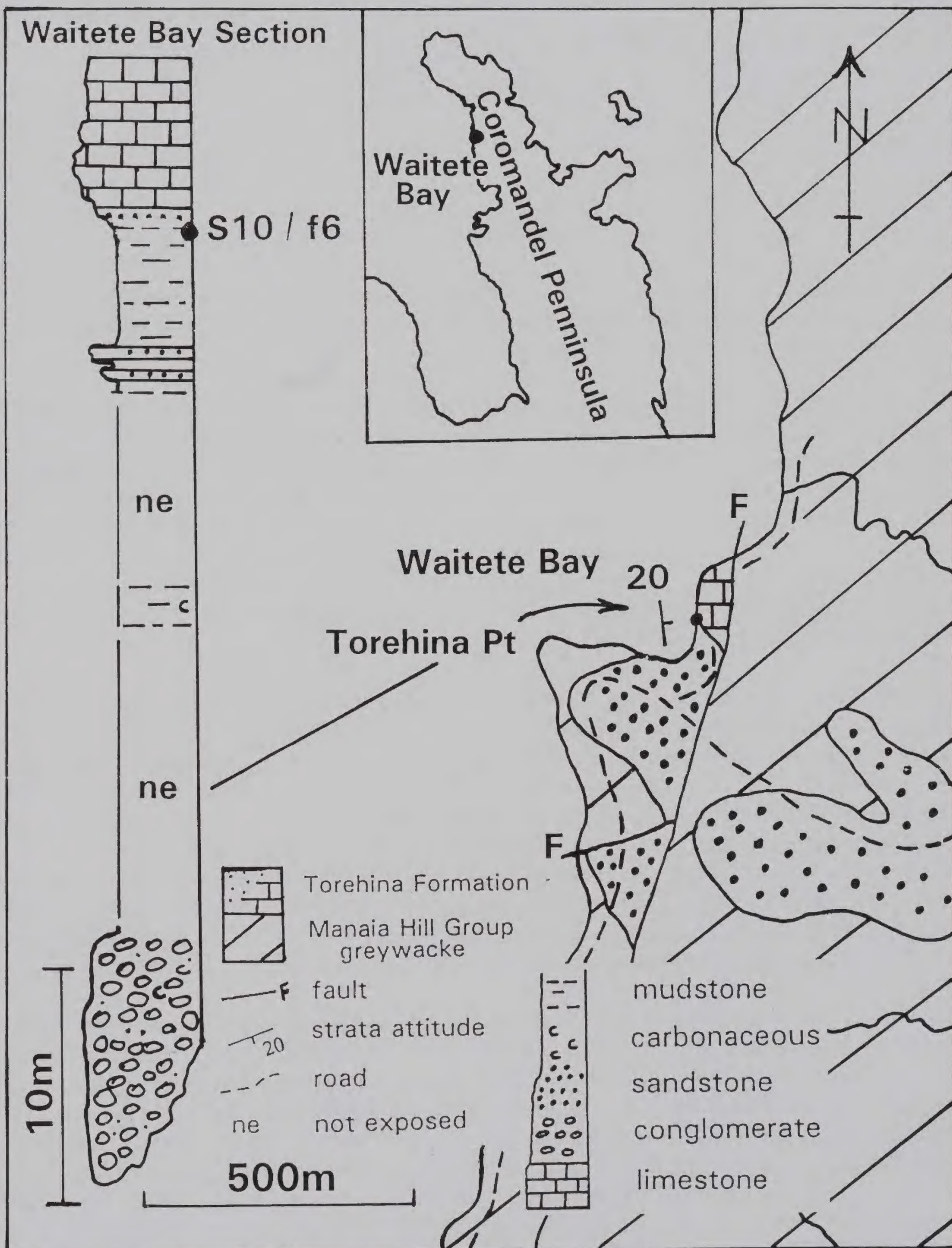


Fig. 1. Geological map of Waitete Bay area of Northern Coromandel Peninsula, with stratigraphic column for the Oligocene Torehina Formation fossil locality.

between *"P." stellatus* and the Waitete Bay specimens indicate that the latter are not *Nielsenicrinus stellatus* (Hutton), but are a new species.

Generic names have been assigned to many isocrinids on the basis of stem physiology (Rasmussen 1961). Crinoid researchers, amongst them Moore (1939) and Donovan (1984, 1988), although expressing reservations concerning this method of identification, recognise the lack of diagnostic calices in preserved material and acknowledge columnal diversity. Many taxonomic allocatons have been made on the basis of morphological criteria derived from crinoid columnals (Moore, Jeffords & Millar 1968; Roux 1977; Donovan 1984, 1988; Stukalina 1988). These have been based mainly on patterns of columnal articulation, size of basals, and arrangement of cirrus sockets, whereas Recent genera and a few established (well preserved) fossil genera are based mainly on brachial ramification and articulations (Rasmussen 1978; Donovan 1987).

SYSTEMATICS

Class	CRINOIDEA Millar, 1821
Subclass	ARTICULATA Zittel, 1879
Order	ISOCRINIDA Sieverts-Doreck, 1952

Family	ISOCRINIDAE Gislen, 1924

Articulate crinoids in which the articular face of the columnals has lanceolote to subguttiform petals surrounded by adradial and marginal crenellae. The crenellae attain their greatest length about the gradual transition from marginal to adradial position. The length of internodes is 6-17 internodals, with fewer located in the proximal region of the column. The nodals are larger than internodals with five large elliptical cirrus sockets facing outwards.

Genus	*Nielsenicrinus* Rasmussen, 1961
Type species:	*Pentacrinus obsoletus* Nielsen, 1913; original description. Paleocene (Upper Danian), Denmark.

The genus *Nielsenicrinus* was originally established to include a group of Cretaceous Isocrinidae in which a syzygial articulation I Br 1-2 is combined with a synarthrial articulation II Br 1-2. It has been found in the Upper Cretaceous and Lower and Middle Paleocene of Europe (Austria, Belgium, Denmark, England and France).

Rasmussen (1961) distinguished *Nielsenicrinus* spp. from *Isocrinus* spp. using differences in brachial articulation and calyx characteristics. Although the Waitete material consists solely of columnals, a confident generic allocation is made based on the following: A. articular face - more pentalobate than stellate in outline; a pentamerous lumen surrounded by a smooth perilumen; a lack of radial and ligmental pores common in *Isocrinus;* long, narrow lanceolate areolae instead of short, broad areolae common in *Isocrinus* (Moore & Vokes 1953; Rasmussen 1961, 1978; Klikushin 1979, 1982); the crenullae attain their greatest length about the gradual transition from marginal to adradial position (Rasmussen 1961). B. pluricolumnal - cryptosymplectical instead of syntosial articulation between the nodal and infranodal; elliptical cirri sockets exhibit circular cirral axial canal and fulcral ridge with tubercle terminations (Rasmussen 1961).

Nielsenicrinus waiteteensis n.sp. (Figs. 2-4, 6, 12, 16)

MATERIAL

Holotype. AK71631 (Auckland Institute and Museum), internodal columnal.

Paratypes. AK71632, pluricolumnal; AK71633, internodal columnal; AK71634, pluricolumnal and internodal columnal; AK71635 and AK71636, internodal columnals; AK71637, 17 specimens (a-q) columnal and pluricolumnal. E518, E519 (University of Auckland, Geology Department), separate internodal columnals.

Measurements and meristics of the columnals of eight specimens of *Nielsenicrinus waiteteensis* n.sp. are listed in Table 1.

TYPE LOCALITY AND AGE

Fossil Record File number S10/f6; grid reference S10/289010 (NZMS 260 1:50 000 map), Torehina Formation, Waitete Bay, Coromandel, New Zealand. Duntroonian (Ld) (Chattian), late Oligocene (Eagle & Hayward 1993).

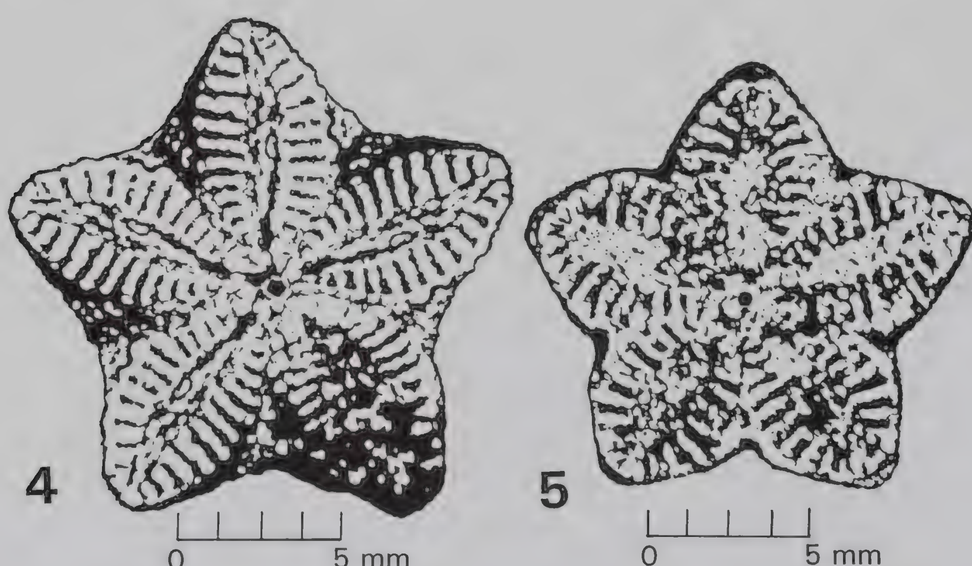
DESCRIPTION

The column is smooth, pentalobate to stellate in transverse section. Height of the columnals is 0.5-2.7 mm. Columnal diameter is almost constant; higher columnals are slightly raised at the centre of the columnal. Radial depressions at the suture are distinct in some specimens. Pluricolumnals exhibit succeeding columnals with pronounced alternating height; columnals may be more lobate so that the longitudinal radial furrows transect the articular face. Lateral sutures are finely crenulate. Columnal articular face possesses narrow, regular, elliptical, inter-radial petals, each surrounded by 26-28 culmina; half reach the periphery with the rest adradial. Lateral peripheral and radial crenulation is evenly joined. Crenellae reach their greatest length at the transition from marginal to adradial position. A small, smooth,

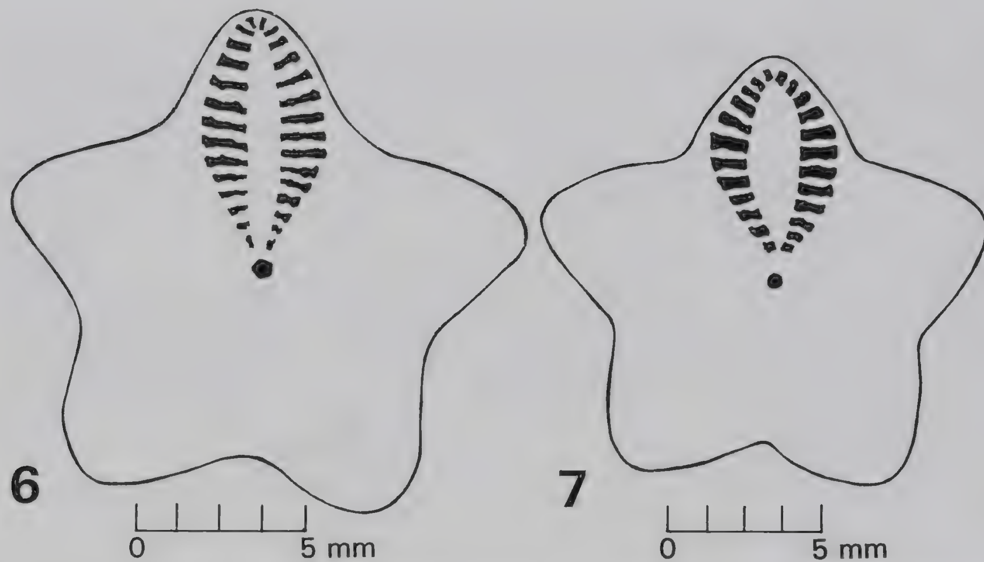
Table 1. Measurements (mm) and meristics of the columnals of eight specimens of *Nielsenicrinus waiteteensis* n.sp.

Specimens	AK 71631	AK 71632	AK 71633	AK 71634	AK 71635	AK 71636	E 518	E 519
Greatest inter-radial length	4.2	3.9	3.9	4.0	4.0	4.3	4.0	4.3
Greatest radial length	3.3	3.0	3.2	3.1	3.3	3.1	3.1	3.1
Inter-nodal height	1.1	0.5-1.4	1.2	1.9	1.1	1.2-1.7	2.0	2.2
Nodal height	–	2.7	–	–	–	–	–	–
Mean no. of peripheral crenullae per section	14	–	12	13	13	13	13	12
Mean no. of radial crenullae per section	14	–	14	13	13	13	13	14

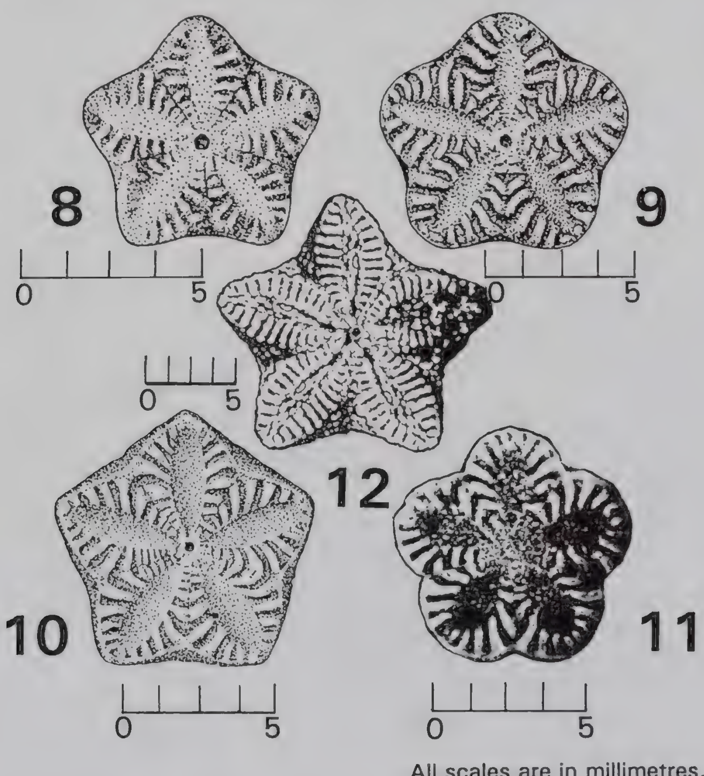
Figs. 2-3. *Nielsenicrinus waiteteensis* n.sp., Duntroonian stage, Torehina Formation, Waitete Bay, Coromandel. 2. Proximal view of the internodal articular face of the holotype AK71631. 3. Nodal elliptical cirral socket showing circular axial pore and fulcral ridge of the paratype AK71632.



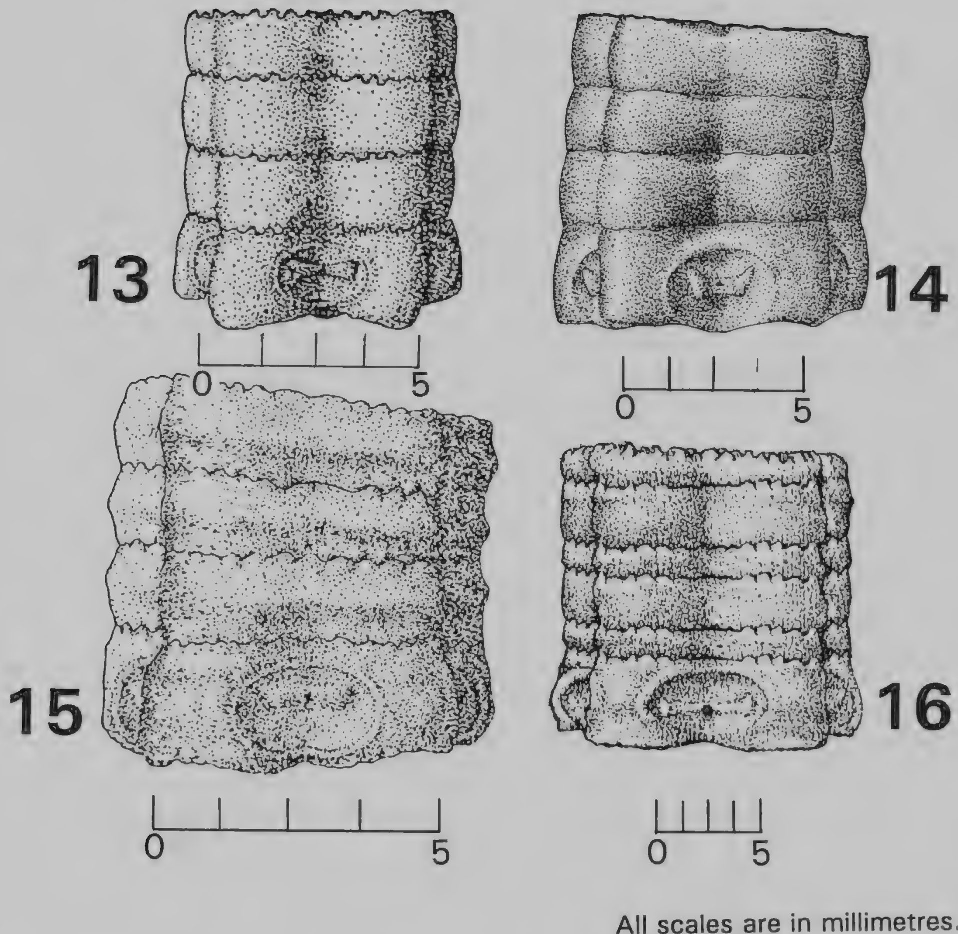
Figs. 4-5. Comparable proximal articular faces. 4. Composite line drawing of the articular face of an internodal of *Nielsenicrinus waiteteensis* n.sp., paratype AK71633 from limestone at Waitete Bay, Coromandel. 5. Line drawing of the articular face of an internodal of *Pentacrinus stellatus* from Point Elizabeth Beach, Westland, South Island.



Figs. 6-7. Internodal articular face comparison of the petal, areolae, and number of culimina. 6. *Nielsenicrinus waiteteensis* n.sp. 7. *Pentacrinus stellatus.*



Figs. 8-12. Comparable proximal articular faces of *Nielsenicrinus* spp. 8. *N. obsoletus.* 9. *N. cretaceus.* 10. *N. rosenkrantzi.* 11. *N. varians.* 12. *N. waiteteensis* n.sp. (8-10 after Rasmussen 1961; 11 from Klikushin 1982.)



Figs. 13-16. Comparable lateral views of pluricolumnal stems of *Nielsenicrinus* spp. 13. *N. obsoletus*. 14. *N. cretaceus*. 15. *N. rosenkrantzi*. 16. *N. waiteteensis* n.sp. (13-15 after Rasmussen 1961.)

radial area exists between petals, in from the periphery. Axial canal narrow, sub-pentagonal. Lumen contained within a narrow, raised ridge, continued in the adradial crenulation. Perilumen interrupted, smooth. Nodals slightly higher and often more robust than internodals. Nodal and internodal surfaces are smooth and slightly tumid. Articulation between nodal and infranodal cryptosymplectical. Cirrus sockets elliptical and cover most of nodal height. Upper margin of cirrus socket protruding. Cirrus axial canal sited slightly above socket middle beneath an articular ridge with enlarged tubercle ends. Internodal length unknown. Cirri, theca, brachials, and pinnules also unknown.

ETYMOLOGY

Named after the type locality, Waitete Bay.

FAUNAL ASSOCIATIONS

McKay (1897), Park (1897), Fraser & Adams (1907), Kear (1955) and Skinner (1969) list fossil macrofauna from the limestone of Waitete Bay. Eagle and Hayward (1993) provide a paleontological and paleoenvironmental assessment of the macrofauna found at this fossil locality. All taxa appear *in-situ.*

DISCUSSION

Columnal descriptions of *Nielsenicrinus* spp. by Rasmussen (1961) show the proximal internodal articular face of the type specimen of *Nielsenicrinus obsoletus* (Nielsen, 1913) (Figs. 8, 13; Mineralogical and Geological Museum of Copenhagen no. 8884, Upper Danian age, recovered at the base of the Paleogene at Svanemollen in Copenhagen, Denmark) to be the most similar to specimens of the Torehina Formation of Waitete Bay. Of similar columnal shape, the main differences are that *Nielsenicrinus waiteteensis* n.sp. possesses: narrower culimina of greater length about the gradual transition from marginal to adradial position; greater number of culimina per petal (26-28 compared with 18-20); narrower petal areolae; and a much larger inter-radial space. Morphological comparison with other species of the genus shows that: *Nielsenicrinus cretaceus* (Leymerie, 1842) (Figs. 9, 14; Geological Survey, London, no. 1577, from the Cenomanian Grey Chalk, Folkstone, England), possesses no inter-radial spaces, has fewer culimina per petal (14-18), and culimina are aborally uneven. *Nielsenicrinus rosenkrantzi* Rasmussen, 1961 (Figs. 10, 15; Mineralogical and Geological Museum of Copenhagen no. 8882, Maastrichtian, Stevens Klint, Denmark), possesses reduced inter-radial spaces, has merging petal culimina, fewer culimina per petal (20-23), and is elliptically broader in petallic areolae. *Nielsenicrinus varians* Klikushin, 1980 (Fig. 11; Leningrad Mining Institute no. KM-7-3, Danian, Mangyshlack, Crimea), is more pentalobate in shape, marginal culmina are wider, culimina petalicly interwoven, with fewer culimina per petal (12-16), and a circular lumen.

The calyx of *Nielsenicrinus waiteteensis* is unknown. Lack of preservation may be due to predation by fish while live, or scavenging at death by epifaunal or infaunal organisms (Maples & Archer 1989). The stalk probably extended to a length of 0.6-1.5 m. The recovery of only mature columnal ossicles must be considered in light of the fact that stalks of extant isocrinids continue to grow and shed terminal columnals. The discovery of pluricolumnals, however, does not support the concept of ontogenetically discarded distal ossicles in this species, and would suggest death *in-situ.* Because of similarities to European *Nielsenicrinus* species, it is suggested that *N. waiteteensis* is a Cenozoic remnant of a Tethyan fauna that migrated to New Zealand before or during the Cretaceous.

The presence of a benthic, semi-sessile invertebrate such as *Nielsenicrinus* in a shallow inner-shelf environment of late Paleogene age conflicts with the findings of Meyer & Macurda (1977). In their discussion of the adaptive radiation of comatulid crinoids (mobile feather stars), they state that stalked articulate crinoids disappeared globally from shallow-water environments in the mid to late Mesozoic. Bottjer & Jablonski (1988) corroborate this trend, further stating that isocrinids became restricted to middle-shelf and deeper environments during the late Cretaceous and further restricted to outer-shelf and deeper environments in the Eocene, retaining this environmental distribution to the present. There are, however, a few references to Cenozoic isocrinids found in shallow-water strata (late Oligocene, Germany

(Kutscher 1980); late Paleocene, New Jersey (Weller 1907; Greacen 1941)). All Isocrinida enjoyed a wide environmental range in the Early Cretaceous. It appears that *Nielsenicrinus waiteteensis* was able to persist at the earlier shallow depth in the late Oligocene, Duntroonian Stage.

It has been proved that extant pelmatozoan crinoids (stalked, sessile sea lilies) occur at variable depths and in a wide range of marine habitats (Agassiz 1888). Isocrinids occur today on a wide variety of substrates (Messing 1984). It is suggested that they were, as they are now, numerically important members of several benthic hard and soft ground assemblages (Bourseau & Roux 1984). Some genera have distinct bathymetric ranges of several hundred metres at least, whereas others have depth ranges of little more than 50 m. Although no evidence of an anchoring mechanism such as a holdfast, terminal rootlets, or expanded columnal base (as described by Clark (1977)) has been found, this is not a prerequisite for any isocrinid to attach and live on a lithified substrate or an unconsolidated surface (Messing 1984), nor does it mean that *N. waiteteensis* did not possess such mechanisms.

Compared to other fossil isocrinids the columnals of *Nielsenicrinus waiteteensis* are particularly large. The inclusion of a calcareous skeleton such as that within *Nielsenicrinus* produces a self-sustaining growth advantage, and it seems that *Nielsenicrinus waiteteensis* used this factor to increase stem area two-fold. Larger stem columnals have meant an overall increase in stem area which has also increased by the adoption of a dense stellate stem ossicle shape. These factors have produced a third more surface area for support and structural strength compared with many other members of the subclass Articulata. This development would require a constant, rich source of nutrient to facilitate proportional growth. It is possible that *Nielsenicrinus waiteteensis* was partitioning available (otherwise locally unused) food resources to help in this. Ausich (1980) has already proposed that this was a reality for multi-tiered assemblages of fossil crinoids such as isocrinids, however, it is also apparent from other fossil faunas collected (Eagle & Hayward 1993) that the temperate, inner-shelf biotope at Waitete Bay was at least moderately nutrient-rich.

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